

L. Strow

#### Three Years of CO<sub>2</sub> Retrievals with AIRS

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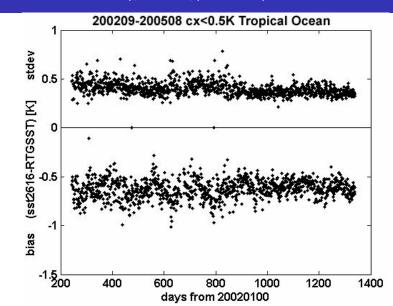
September 26, 2006

- During RTA validation found that CO<sub>2</sub> growth rate impacted results
- Variable CO<sub>2</sub> must be taken into account for climate-quality results from AIRS (and RTA validation);
- V5: Single fixed growth rate, no latitude dependence
- Retrievals of CO<sub>2</sub> using only AIRS data have concentrated on upper-trop channels and have not examined long time-series.
- We use ECMWF (independent T(p)?) and NOAA/CMDL MLO CO<sub>2</sub> to examine AIRS sensitivity to CO<sub>2</sub> and implications for radiometric stability
- Calibrate AIRS CO<sub>2</sub> channels with MLO (altitude close peak of weighting functions for channels used here).
- Apply results to other latitudes. Use channels with different T(p) sensitivities to evaluate possible ECMWF T(p) errors.
- Use "uniform\_clear" subuset of clear ocean FOVS generated at LIMRC



AIRS Radiometric Stability via SST Obs (Aumann: JGR 2006)

0.2K absolute accuracy, <0.016K/year stability for 2616 cm<sup>-1</sup> channel

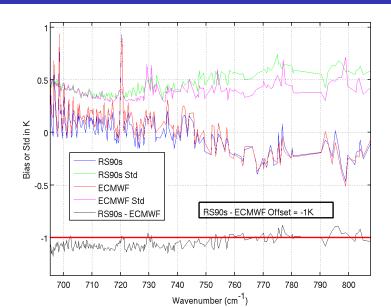




#### Validation: Coincident RS-90's vs ECMWF

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I Camarr



#### Channel Selection: CO2

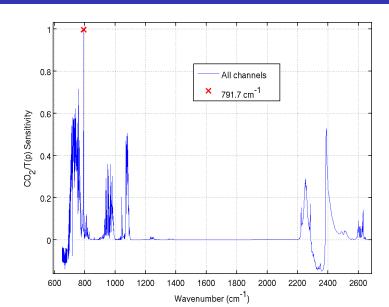
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- Need to use mid- to lower-tropospheric channels since "truth" is known there (Mauna Loa record).
- ECMWF fields are largely unbiased relative to radiosondes for lower- to mid-trop, esp. Northern Hemisphere. (private comm. R. Engelen).
- Retrieve CO<sub>2</sub> from AIRS radiances using ECMWF for T(p).
- Compare retrieved  $CO_2$  to NOAA/CMDL MLO, located at  $\sim$ 650 mbar.
- Test sensitivity to ECMWF T(p) by using channels with very different temperature sensitivities.
- Pick CO<sub>2</sub> channels away from interferences
- Channels: 791.7 cm<sup>-1</sup>, and 2392-2400 cm<sup>-1</sup>, CO<sub>2</sub> W.F. peaks around MLO altitude.



#### Ratio of CO<sub>2</sub> to T(p) Jacobians

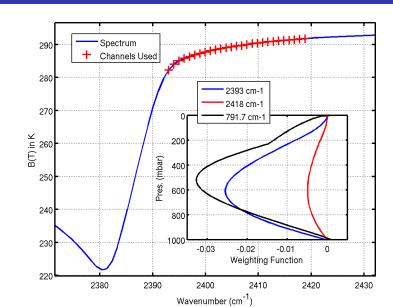






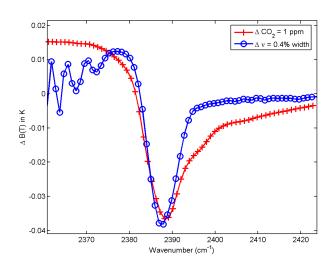
#### CO<sub>2</sub> Retrieval Using Shortwave Channels

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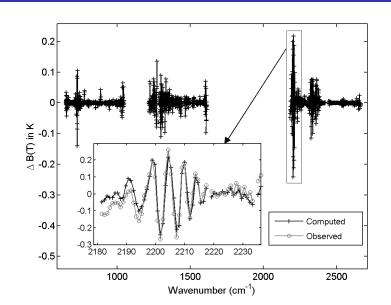
### But: Need Better AIRS Frequency Calibration!





### AIRS Radiances Have a 1-time offset in Nov. 2003: Avoid





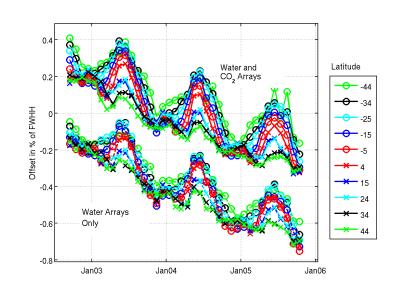


#### AIRS Freq. Cal. Results

Daytime Frequency Shifts (Nov. 2003 Corrected)

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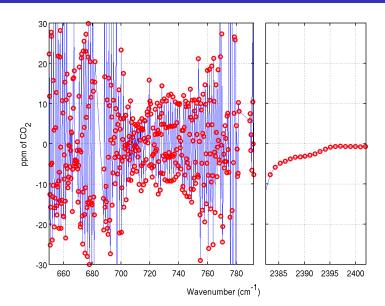
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#### Translation of Freq. Cal. into CO<sub>2</sub> Errors

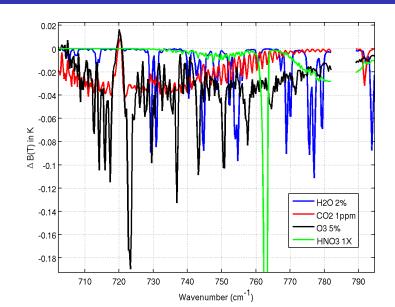
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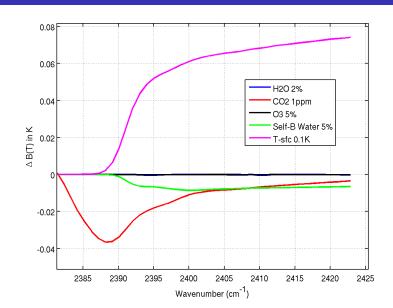
## Contamination of CO<sub>2</sub> Channels by Other Gases: LW

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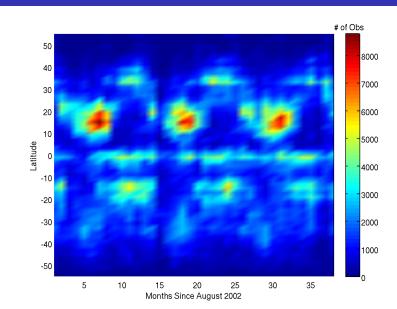
#### Contamination of CO<sub>2</sub> Channels by Other Gases: SW



- $BT_{obs} BT_{calc}(ECMWF) = \frac{dB}{dCO_2} \delta CO_2 + \frac{dB}{dT} \delta T_s$
- SW: 2392-2420 cm<sup>-1</sup>, all channels used for both CO<sub>2</sub> and Т
- LW: 791.7 cm<sup>-1</sup> used for CO<sub>2</sub> and  $T_s$ ; 790.3 and 801.1 cm<sup>-1</sup> used for  $T_s$  only.
- CO<sub>2</sub> and  $T_s$  solved for each profile, Start with 2616 cm<sup>-1</sup>  $T_{\rm s}$ . Probably solving for emissivity at 2400 cm<sup>-1</sup>, residual  $H_2O$  and emissivity at 791 cm<sup>-1</sup>.
- Median CO<sub>2</sub> and  $T_s$  binned for 1 deg. latitude bins
- 38 months of data analyzed
- Error analysis not complete



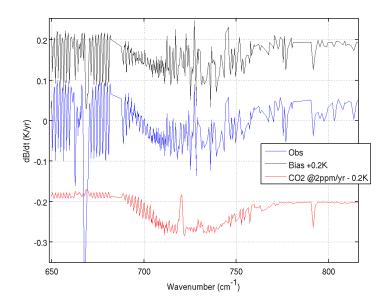
#### **Clear FOV Observation Statistics**





#### CO<sub>2</sub> Signal with *no* ECMWF (blue): LW

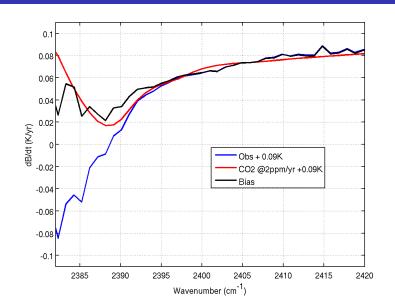






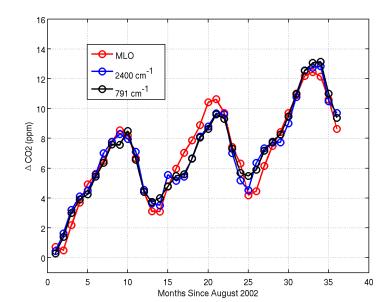
#### CO<sub>2</sub> Signal with no ECMWF (blue): SW





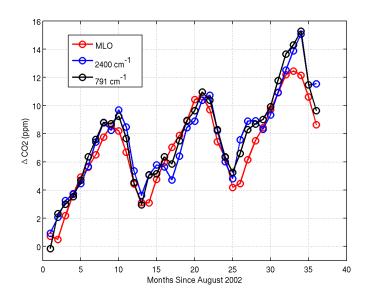


### ASL AIRS CO<sub>2</sub> Retrievals -7 to +43 Deg. Lat.





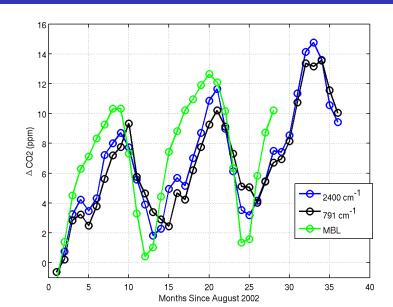
### ASL AIRS $CO_2$ Retrievals $\pm 5$ Deg. Lat.





# AIRS CO<sub>2</sub> Retrievals 35-45 Deg. Lat., +NOAA/MBL

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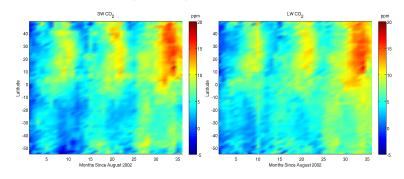




## AIRS 3-Year $CO_2$ , SW and LW Correlation = 0.89

Three Years of CO<sub>2</sub> Retrievals with AIRS

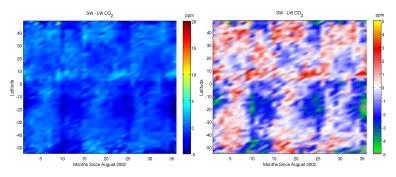
Left: Shortwave Right: Longwave



#### SW minus LW AIRS CO<sub>2</sub>

Three Years of CO<sub>2</sub> Retrievals with AIRS

Left: -5 to +20 ppm Right: -5 to +5 ppm

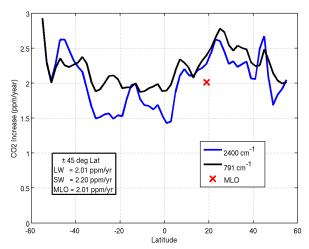




#### Mean CO<sub>2</sub> Growth Rate over 1st 3 Years

Three Years of CO<sub>2</sub> Retrievals with AIRS

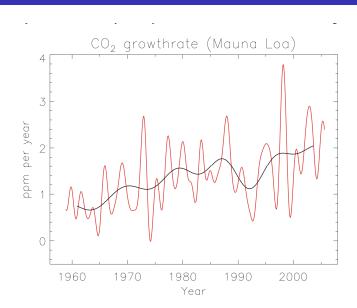
 $\pm 45$  Deg. Lat. SW vs LW rates imply AIRS stability of  ${\sim}0.002$  - 0.006 K/year





#### NOAA/CMDL MLO Growth Rates (Tans)

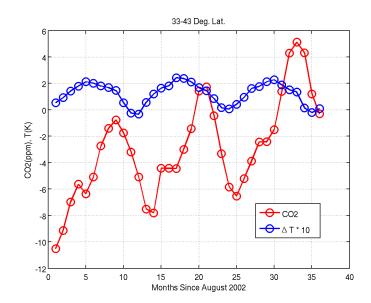






#### Retrieved CO<sub>2</sub> vs T in Northern Hemisphere

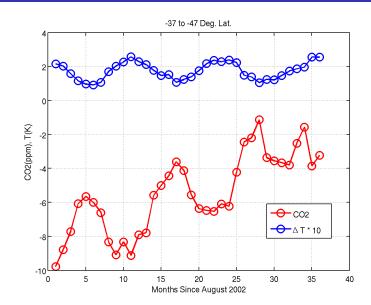






#### Retrieved CO<sub>2</sub> vs T in Southern Hemisphere

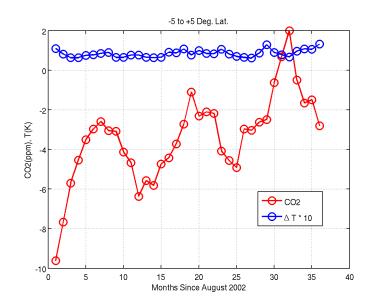
Three Years of CO<sub>2</sub> Retrievals with AIRS





#### Retrieved CO<sub>2</sub> vs T in Tropics

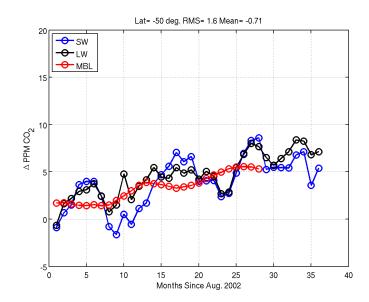
Three Years of CO<sub>2</sub> Retrievals with AIRS





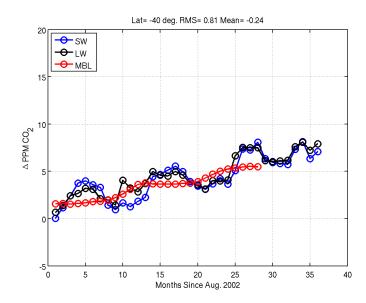
#### SW vs LW vs NOAA/CMDL MBL Time Series

Three Years of CO<sub>2</sub> Retrievals with AIRS

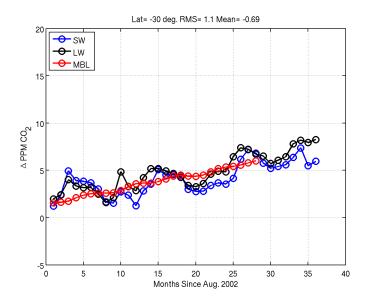




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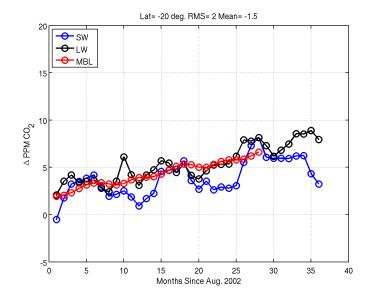






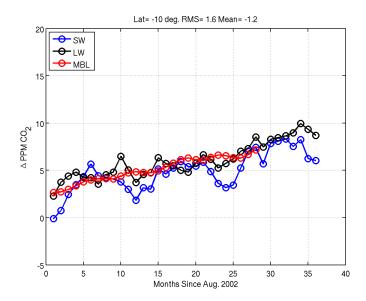


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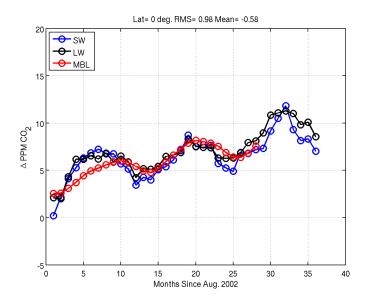






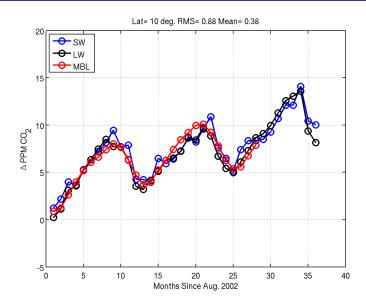






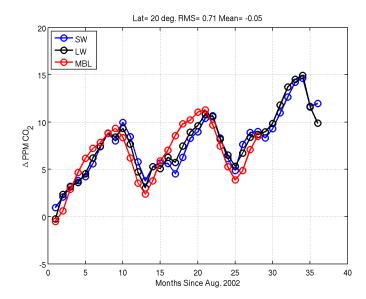


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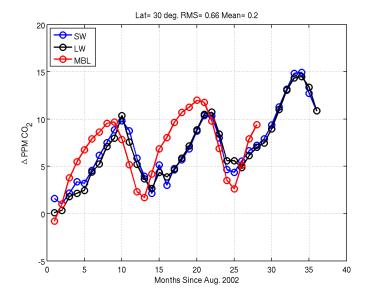


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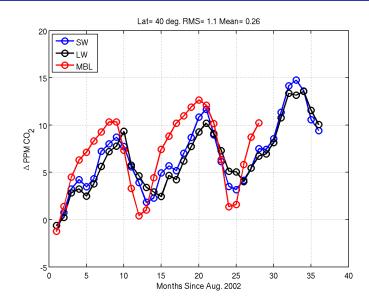






Three Years of CO<sub>2</sub> Retrievals with AIRS

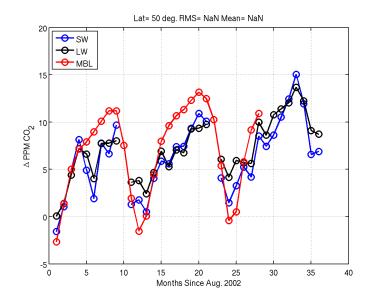
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Three Years of CO<sub>2</sub> Retrievals with AIRS

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#### **Conclusions**

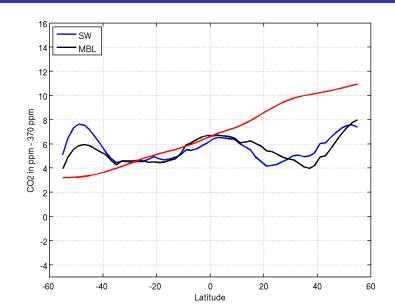
Three Years of CO<sub>2</sub> Retrievals with AIRS

- AIRS radiometric stability at the ~0.005K/year established with 791 and 2400 cm<sup>-1</sup> channels, in agreement with Aumann SST studies.
- AIRS sees phase delay from surface to mid-trop CO<sub>2</sub> transport
- Potentially retrieve CO<sub>2</sub> growth rates versus latitude, good agreement with NOAA/CMDL MLO in-situ measurements
- Results dependent on UMBC spectral calibration



# ASL Jan 2004: Red: NOAA/CMDL MBL

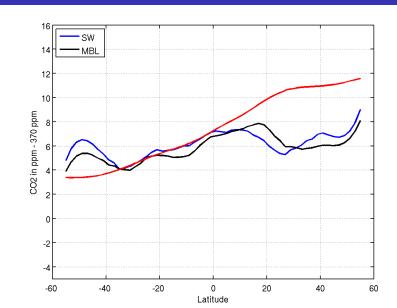






### Feb. 2004: Red: NOAA/CMDL MBL

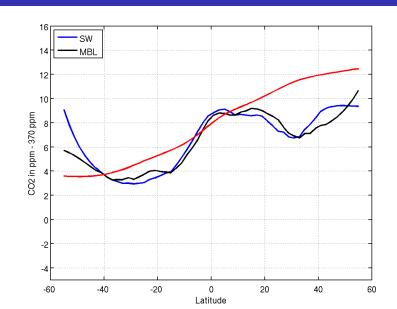






### Mar. 2004: Red: NOAA/CMDL MBL

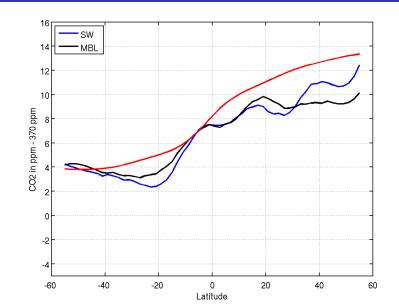
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# ASL Apr. 2004: Red: NOAA/CMDL MBL

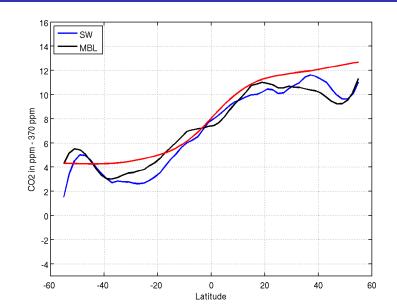






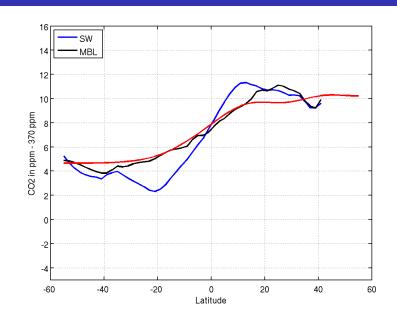
### May 2004: Red: NOAA/CMDL MBL





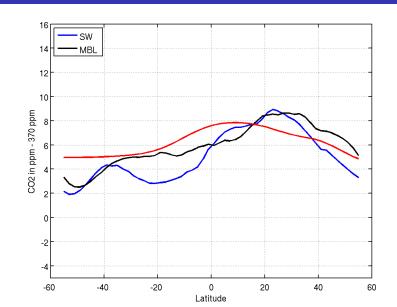


## ASL June 2004: Red: NOAA/CMDL MBL





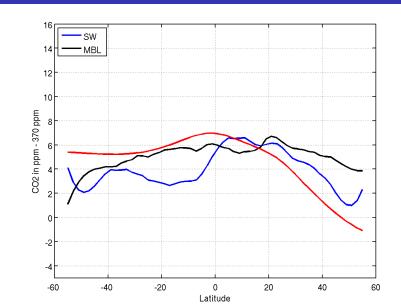
# ASL July 2004: Red: NOAA/CMDL MBL





## ASL Aug. 2004: Red: NOAA/CMDL MBL

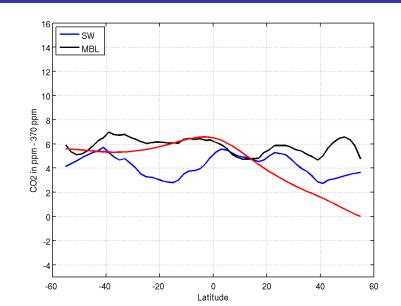






### Sept. 2004: Red: NOAA/CMDL MBL

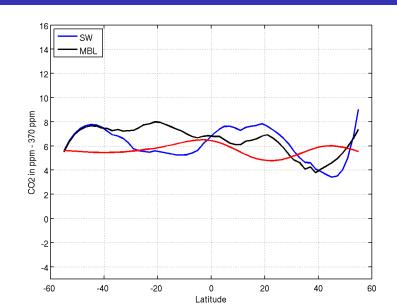
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### Oct. 2004: Red: NOAA/CMDL MBL

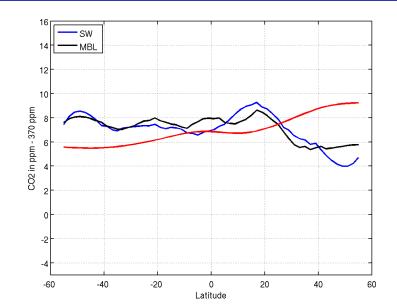
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### Nov. 2004: Red: NOAA/CMDL MBL

Three Years of CO<sub>2</sub> Retrievals with AIRS





### Dec. 2004: Red: NOAA/CMDL MBL



